EMDS Science and Practitioner Review Panel
North Coast Watershed Assessment Program

Purpose
- Review the scientific basis for the structure and parameterization of the North Coast Watershed Assessment (NCWAP) Ecological Management Decision Support (EMDS) model;
- Review the data inputs used in the model;
- Establish the practical uses and limitations of the model for identifying stream reach and watershed conditions and for guiding restoration project and land management activities.
- Provide guidance to improve the design and implementation of the NCWAP EMDS model.
- Provide guidance on any long-term process that may be needed to ensure the scientific basis and appropriate use of the NCWAP EMDS model and its outputs.

Management
- Richard Standiford from University of California Cooperative Extension and UC Berkeley Center for Forestry managed the panel, under contract from the California Department of Forestry and Fire Protection (CDF).
- Russ Henly, CDF, is the contract manager.
- Contract funds were used to support travel and honoraria (where required) for the panel participants.

Process
Nine panel members agreed to participate in the review (see Appendix 1). They represented a cross-section of watershed disciplines (fisheries, hydrology, geomorphology, forestry) and employers (forest products industry, resource management agencies, research institutions, natural resource consultants). Each panel member received general information on the EMDS model and specific information on the use of the model by NCWAP in advance of a two-day workshop to review and discuss the model. The workshop was held on April 11-12, 2002 at the UC Cooperative Extension 4-H Conference Center in Rohnert Park. The meeting was conducted by the UC Berkeley Center for Forestry, with local assistance from the University of California Cooperative Extension Sonoma County office. Appendix 2 shows the agenda for the meeting.

NCWAP staff from the California Department of Forestry and Fire Protection (CDF), California Department of Fish and Game (CD F&G), California Geological Survey (CGS), and The Resources Agency (TRA) participated as presenters and discussants (list included in Appendix 1). At the workshop, the NCWAP EMDS model and the data inputs used with it were presented in detail by the NCWAP team. Discussion about the model and its data sources were carried out, and practical implementation issues explored. Feedback on both science and implementation issues were solicited during the workshop. General comments from the workshop are shown below. In addition, follow-up letters were received from several of the participants which provide further comments on EMDS (see appendices 3 to 8).

General Comments

In general, the review team found the EMDS system to be a good way to start to evaluate fish habitat in the NCWAP assessment. The following statement, provided by Dr. George Ice, gives a good overview of the results of the EMDS modeling effort to date:

> *"The team working on the EMDS tool has made remarkable progress in adapting an expert decision tool developed for federal lands in the Pacific Northwest to the difficult task of assessing watershed conditions in California. Still, both the NCWAP staff and experts who reviewed the current status of the EMDS tool find that many of the fuzzy logic functions and weighting/combinational rules are "exploratory" or best guesses, based on scant information. The EMDS can be characterized as a yet-to-be validated working hypothesis of the factors that define watershed condition. It should be viewed as pilot project requiring calibration and validation of the tool. Two key remaining questions include: are EMDS results consistent with observed differences in fish populations for subbasins; and are data collected as part of NCWAP watershed assessments sufficient to support the EMDS model and at what scale?"*

One key issue raised in the review process is that the overall model structure combines current condition, potential habitat, risks, and potential for restoration into one general model. There was near unanimous agreement that the overall structure of the model should be refined into four separate submodels. These would address:

1. Potential resource value – The model currently does not distinguish between areas that are low in their quality but capable of restoration, and areas that have historically been poor streams for anadromous fisheries. There needs to be some designation of where potentially good streams might be located. Some reaches may always be unsuitable. There needs to be a "fair call" about a stream's condition.
2. Current watershed habitat condition – The current status quo of the various streams should be highlighted.
3. Relative hazards in the watershed – There should be some designation of the relative hazards in a watershed, including upslope management practices, fish barriers, road systems, landslide risk, etc.
4. Potential future conditions of the watershed – This would highlight where current conditions or hazards (2 and 3 above) could be mitigated for potentially high value streams (1 above).

The current model does not allow for analysis of alternatives, restoration potential, or monitoring, since it combines so many diverse elements of the watershed into one output. Breaking the model into these four component parts would facilitate real analysis. For example, comparing the Relative Hazard in a watershed at time 2 to time 1, would allow one to evaluate if conditions were getting better or worse. Breaking the model into these various components would also make it easier to evaluate limiting factors to fish viability.

The reviewers agreed that the modeling effort will change and improve as additional information is gathered, and learning about watershed processes takes place. A great deal of headway has been made already. General modeling for assessments should aim to derive hypotheses about ecosystem processes. There will be a balance between the transparency of EMDS, and the more rigorous process-based approaches that will be developed over time. The process model is needed before NCWAP can realistically expect to meet its goal of being used to guide restoration efforts. Restoration should be on streams with high potential (submodel 1), that have hazards (submodel 3) that can be mitigated with restoration.

Model Structure and Data

There needs to be more transparency about the confidence and availability of the data used to derive model results. As future revisions are evaluated, the team needs to strive towards model parsimony. It seems that several of the variables are highly collinear, and could perhaps be streamlined.

The review team felt that keeping unfilled nodes in the model is important to evaluate where future data acquisition is needed and describe what drives the process. It should be clear in the model outputs, however, where values derived are for areas with missing data.

The model documentation should provide a clear statement of what each node is describing, the nomenclature, and the source of the data or literature for the various breakpoints.

Stream Reach Model

The review team expressed some concerns that the data collected for the stream reach model was originally collected for some other purpose. It seemed that the stream reach model was constructed on the basis of data that already existed. The more appropriate approach would be to develop a set of hypothesis from the literature about variables that are important for stream reach condition for salmonid habitat, and then designing an efficient field sampling method to derive statistically valid data for a stream reach. There is a need for statistically valid watershed monitoring data for the various reaches to be brought into model.

The team pointed out that stream conditions exhibit high variability within and between years. Stream reach surveys collected at one point in time misses this variability. Future efforts should be devoted to developing process based models that captures the temporal variability of stream characteristics, and describes the probability density function for these parameters.

Questions were raised about the justification for taking three stream temperature measures. This implies a false level of precision and may be an inefficient use of field sampling effort. Future efforts should investigate spatial temperature models (i.e. the desktop modeling effort developed by Stillwater Sciences). This could be calibrated for an area, and would address spatial variability.

Better characterization of the riparian zone is needed. Canopy density measures should be modified based on stream channel characteristics. The stream reach model for woody debris recruitment is currently based on tree mortality. Research shows that this is not necessarily the dominant recruitment process (bank undercutting and landslides may be more important sources). Each woody debris recruitment process has a different probability curve.

There was some skepticism about the likely success in building an effective reach scale model. An alternative approach suggested was to use field reach sampling to validate remote sensing data. Perhaps the team should carry out a sensitivity analysis. Does the reach model, appropriately scaled up to give watershed conditions, give consistent, repeatable results? How does this compare to results from remote sensing?

Model Improvements:
The team may wish to consider food source as a component of the model. The current focus on habitat passes over the energy flow in the system.

There should be an attempt to incorporate sediment budgets into the EMDS model where these have been carried out. These could be incorporated using SOR statements, and could provide appropriate weights for the various nodes. Similarly, road inventories, and TMDL analysis adds additional insight, that could improve the model for areas where these have been completed.

The model currently has no hydrological streamflow information. It is understood that there has not been a budget for construction of gauging stations, however, there are some hydrological modeling tools, using DEMs that might help to provide additional information. This might help to show areas where base flow is too low (low potential in submodel 1 above) for the stream to be considered good anadromous habitat. It might also help to address seasonal flows, and provide estimates of peak flows. The modeled flow data could be combined with information on stream diversions (available from Division of Water Rights) to further refine the model.

Passage barrier information is needed. This often exists as part of the general road inventory, or sediment budget. The role of barriers varies based on whether resident or anadromous fish are considered.

The landslide data does not appear to have been completely captured in the EMDS system. It may be useful to utilize the landslide maps to provide rate of sediment delivery for different slope classes.

The scaling of the output does not appear to make comparisons between various watersheds possible. The review team suggested greater use of the model on reference watersheds to serve as a benchmark for comparison. This would allow for hypothesis testing. For example, are reference streams different than other streams? (are there differences in pool depth, wood recruitment, embeddedness?) Model output could be scaled to appropriate reference watersheds.

Appendix 1 - EMDS Science and Practitioner Review Panel

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Others Present:
Rick Standiford, UCB
Russ Henly, CDF - staff
Dale Cramer, CGS – staff
Scott Downie – CDF&G – staff
Chris Keethley – CDF – staff
Rich Walker – CDF – staff
Steve Kanata – CDF&G – staff
Bill Stewart – CDF – staff
Cathy Bleier – Res. Agency - staff

Appendix 2 - AGENDA

NCWAP EMDS Peer Review Team Workshop
Santa Rosa

Day 1: April 11, 2002

1. Welcome
2. Introductions
3. Objectives
4. Review Agenda

5. Introduction to NCWAP 10:30-10:50 Russ
   Role of EMDS in NCWAP watershed assessments
6. Introduction to EMDS 10:50-12:30
7. Step-by-step Guide through Version 1.1 Models
8. Watershed Model Rich
9. Stream Reach Model Steve
   Lunch 12:30-1:30
10. Watershed Model demonstration (version 1.1) 1:30-2:45 Chris
11. Walk through example, take input from panel for changes and rerunning the model, etc.
12. Show examples of outputs (maps, tables)
13. Hit upon General Issues (through demo/discussion) re:
14. response curves
15. combination rules
16. weightings
17. mainstem vs. tributaries
18. varying grain of data
    Break 2:45-3:00
19. Upgrading EMDS 3:00-5:00
20. Overview of Version 2.0 modifications
21. Stream reach model Steve
22. Watershed model Chris/Rich
23. Nomenclature for rankings Rich
24. Issues yet to be resolved
25. Temperature Steve/Chris
26. Flow Steve
27. Passage Steve
28. Stream reach Steve
29. Check progress and plan agenda for Friday 5:00-5:15 Rick/Russ

Day 2: April 12, 2002

30. Ad Hoc Detailed Examinations of Versions 1.0 and 2.0 (at request of committee members) Steve/Chris/Rich
31. Continue any unfinished items from Thursday
32. Continue Ad Hoc detailed examinations of models
33. Discuss potential for development of a biological EMDS Model for NCWAP
34. Approaches other than EMDS for that might be appropriate for NCWAP
35. Other Feedback and Critique from Peer Reviewers
36. Instructions for peer reviewers for submitting final comments
37. Adjourn by 3:00

Appendix 3 - George Ice Comments

April 19, 2002

Dr. Richard B. Standiford
Associate Dean for Forestry
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Dear Dr. Standiford,

The April 11 and 12 technic al review meeting on the Ecological Management Decision Support (EMDS) tool provided for an open and frank exchange of ideas between the North Coast Watershed Assessment Program (NCWAP) staff and technical review team. I want to thank the NCWAP staff for their presentations, candor, and willingness to consider suggestions from the review team. The following synthesis of my thoughts from the meet are made in the spirit of constructive criticisms.

If I were reporting to a legislative oversight committee on this project I would make the following statement reviewing the status of the EMDS.

The team working on the EMDS tool has made remarkable progress in adapting an expert decision tool developed for federal lands in the Pacific Northwest to the difficult t ask of assessing watershed conditions in California. Still, both the NCWAP staff and experts who reviewed the current status of the EMDS tool find that many of the fuzzy logic functions and weighting/combinational rules are "exploratory" or best guesses, based on scant information. The EMDS can be characterized as a yet-to-be validated working hypothesis of the factors that define watershed condition. It should be viewed as pilot project requiring calibration and validation of the tool. Two key remainin g questions include: are EMDS results consistent with observed differences is fish populations for subbasins; and are data collected as part of NCWAP watershed assessments sufficient to support the EMDS model and at what scale?

Some key steps were identified during the technical review that will improve the defensibility and usefulness of the model. First, the watershed-condition model that is the framework for the EMDS should be as complete as necessary even when information is not available or relationships have not been quantified. The EMDS tool should map out essential factors determining the suitability of a watershed to support fish and where information or understand are lacking, it provides for these types of situations with "conditional ors" or SORs. Perhaps the most practical example of this is the road component of the EMDS. Currently the tool doesn't recognize factors like road surfacing or design (insloped/outsloped). Also, direct delivery of road runoff at stream crossings without adequa te opportunity for sediment settling/trapping, can be the major source of sediment delivery to streams from roads and treatment of these direct-delivery sites can dramatically reduce road sediment loads. Where land managers have detailed road inventory in formation these factors could be evaluated to give a more realistic assessment.

Another potential SOR would be a road sediment model like SEDMODL2 that would utilize GIS data or road inventory data to predict sediment loads.
The architecture of the EMDS allows for documenting the source of fuzzy logic functions. Thorough use of this feature should be encouraged to provide a means of reviewing the tool decision process.

Another very useful suggestion was that the EMDS could use sediment budget information to help weight relative components of the EMDS tool. Currently the tool doesn't account for the relative potential contributions from roads, harvesting, grazing, natural sources, etc. Using information from sediment budgets developed for TMDLs in many of these watersheds could provide more defensible weighting factors. Also, in some cases there appears to be double-counting of watershed conditions like unstable slopes. An excellent recommendation from the review team was to make these situations complementary.

Perhaps the most important recommendation coming out of our meeting is the need to restructure the EMDS to address the differences in what the EMDS tools is assessing. There is currently a mixing of apples and oranges as the EMDS combines current in-stream conditions and relative watershed hazard conditions. Most of the stream condition parameters are judge to be suitable based on best professional judgements about the conditions needed to provide habitat for salmon. In contrast, the road and upland conditions are judged by relative hazards for watershed impacts using the distribution of watershed conditions.

It may be possible in the future to restructure the EMDS to make four different types of assessments. These different assessments are: what could be, what is, what is the relative hazards today, and what is the expected future condition? The in-stream condition and passage barrier portions of the EMDS address the question of what is the current condition? One of the technical panelists stated that this is what the fish are experiencing today. One exception is the large woody debris (LWD) potential parameter that addresses future, not current conditions and should be moved to the relative hazards and expected future assessments.

The upland condition and roads components of the EMDS are currently structured to address the relative hazards of land management in subbasins of the watershed. This is watershed-specific and only addresses relative, not absolute hazards. This can be useful for prioritizing where restoration efforts might be focused but there is a need to also assess what is possible and to understand the difference between the potential and future outputs of sediment, wood, water, and energy.

The NCWAP staff began to explore the question of "what is possible" when they evaluated the data for shade and channel width. Wide channels will tend to have less potential for shade than narrow channels. The NCWAP assessment to develop a fuzzy logic function for shade based on channel width is exactly the right approach and should guide them to how they might address other "potential" logic functions. The natural potential for channel embeddedness might be found to be a function of geology, energy dissipation rate, and perhaps natural wood potential. LWD potential might be assess from the expected wood volumes in a contribution zone. The contribution zone would be determine based on SORs that considers whether the mechanism for wood contribution is a debris torrent or not, and if not whether it is a confined or unconfined channel.

The final assessment would involve not a relative hazard assessment, but an "absolute" assessment that is really a type of sediment, wood, water, and energy budget. This would require that management and natural contributions for each parameter be predicted so that potential, current, and expected future conditions could be compared with similar "currency."

The easiest way of comparing all these different assessment levels and how they combine is the fish passage barrier parameter. The potential for fish distributions (what could be) is the stream network that is suitable for fish minus any natural barriers. The current condition is the stream network suitable for fish minus existing natural and human barriers. The relative hazards in the watershed ranks only the relative difference between the potential and current portions of the stream accessible to fish (which subbasins have a greater or lesser percent of the naturally available stream channel block by human-caused fish passage barriers). The final assessment would assess the future trajectory. Based on the hazards in the watershed can we expect barriers to increase of decrease?

I look forward to the future progress on this tool.

Yours truly,

Dr. George Ice, P.F., R.F.H., C.F.
Forest Hydrologist

Appendix 4 - Bret Harvey Comments

Here's a series of often-related points in no particular order:

1. EMDS seems an effective tool for the display of the correspondence between current physical conditions and idealized fish habitat and watershed conditions. This feature may be useful in achieving the NCWAP goal of "protecting the best" habitat available within watersheds. However, the extent to which such a display supports the additional objectives of NCWAP is not apparent to me.

For example, the claim was made at the meeting that EMDS would be useful in guiding restoration activities. I disagree with this claim to the extent that restoration involves anything beyond "protecting the best." In general, understanding processes is critical to prioritizing proactive restoration efforts. For example, before recommending expending resources on decommissioning roads, one should have an idea of the relative contribution of roads to the future delivery of sediment to streams. Such knowledge would come from an analysis of processes, not a depiction of current conditions.

2. I believe significant drawbacks of EMDS for achieving the goals of NCWAP (e.g. to guide restoration and better implement laws including those that require an understanding of cumulative watershed effects) include the lack of historical context and lack of an explicit incorporation of key physical processes.

These drawbacks could create problems for the assessment of current conditions and in guiding restoration activities. For example, consider a reach of stream that dissects a grassland that has existed for centuries and is unlikely to be cool enough to support some species of salmonids (and thus would acquire a low truth value for habitat suitability in EMDS). In the absence of context, this stream would appear the same as a stream that once was bordered by extensive riparian trees and supported a large proportion of the coho in the watershed, but now is too warm as a result of canopy reduction by streamside logging.

Another example: a detailed map of landslide activity in a watershed might reveal that very old, deep-seated landslides make-up some very large proportion of the total area. In isolation, some people might conclude from such a map that human activities that influence sediment delivery to stream systems in that watershed are irrelevant. This conclusion is absolutely untenable in the absence of estimates of sediment delivery rates from the various features on the landscape: roads, old landslides below recently logged areas, old landslides below uncut areas, etc.

3. The EMDS for watershed condition currently combines measures of contemporary aquatic habitat with parameters that might influence the future condition of aquatic habitat. This feature makes interpretation difficult.

Creation of multiple EMDS models to reflect current conditions, future conditions, and historical conditions (or "potential"), as suggested at the meeting, would alleviate this problem. Please note, however, that all EMDS models of other-than-current conditions would necessarily involve some level of modeling of key processes (e.g., sediment transport, thermal processes), whether the models are formalized or not. Thus, those additional EMDS models would essentially be the products of analyses of sediment, temperature, etc., not essential components of the analyses themselves.

The fact that EMDS models for past and future conditions should be the product of analyses of processes is partly reflected by the difficulty in assigning break points and truth values for so many parameters in the current EMDS watershed condition model, which is made up mostly of parameters the will affect future instream conditions. The current absence of analysis provides no basis for such judgments - that's partly why deciding on the fuzzy relationships is such an ongoing problem.

This concept could be extended to the issue of combination rules raised at the meeting. For example, the weighting of roads and land use in the watershed condition model could reflect the relative influences of these two things on sediment inputs to stream channels (as determined by an overall sediment budget). Here again, the EMDS would be determined by analysis.

4. The negative features of expressing truth values in a relative sense within watersheds seem to outweigh the positive ones. All the parameters for which the "truth value" cannot be estimated in an absolute sense should be evaluated by process-based analysis, not EMDS.

5. My suggestion is to make the central elements of NCWAP analyses of how processes: have produced historic and current conditions, are likely to influence future conditions, and are likely to be altered by restoration activities. I disagree with opinions expressed at the meeting that such efforts would necessitate large, detailed models that are not feasible. Analyses that yielded imprecise estimates would still be useful. For example, temperature modeling efforts might indicate that certain stream reaches accessible to salmonids have warmed from 15 to 25 degrees C (59 TO 77 F) because of reduction in canopy. If such a model is accurate to plus or minus 3 degrees, one could still have an indication that temperature is worthy of consideration in that reach, and (with additional information on relevant processes) what steps if any might most efficiently improve conditions for salmonids.

6. The current decision not to utilize temperature in the reach condition model also provides a reason for developing an understanding of the determinants of key parameters (= an understanding of processes). Model estimates of water temperatures throughout the stream network using existing point measurements would be MORE than adequate to include water temperature as a key element of all three current watershed assessments. On the other hand, most people would probably consider the failure to include water temperature a significant weakness. Why? Because they are building crude temperature models in their heads that indicate thermal regimes have changed dramatically in some sections of the watershed under consideration, and they have concluded that those changes have probably had significant consequences for fish.

7. Linking habitat-based EMDS results to biological responses is clearly highly desirable. In fact, one alternative would be to use biological variables to DETERMINE the specifics of the EMDS model (that reflects current conditions). Unfortunately, strong relationships between biological variables and some overall measure of idealized habitat are unlikely using sub-watershed scale data...

8. Whether or not to include biological elements in the current EMDS model (particularly the reach model that reflects current conditions) remains unclear to me. However, given recent information on the significance of marine-derived nutrients to salmonids (e.g. Bilby et al. 2001, Fisheries 26(1):6-14), and the use of carcasses in current management strategies to increase the production of salmonids, I think recognizing the potential significance of MDS makes sense. One obvious difficulty is the lack of solid information on the role of carcasses in this geographic area...

Appendix 5 - Steve Ellen Comments

Delivered-To: standifo@nature.berkeley.edu
Date: Fri, 19 Apr 2002 16:40:00 -0400
From: "Stephen D. Ellen" <SEllen@compuserve.com>
Subject: EMDS post-workshop comments

Rick,

Here, after a few days' thought, are my comments on EMDS. Please see all of this in the positive light that is intended. I would be happy to talk further on these subjects.

Thanks for the great meeting,

Steve

Post-workshop comments on EMDS, by S.D. Ellen, 4/19/02

Transparent as the EMDS model may be, it takes a while to see through to its basics. In the review meeting, we all sort of poked around at the EMDS beast, testing from our various perspectives its different parts and purposes. We got a good start, but there is more to say.

I believe EMDS is basically flawed in any attempt to combine values for the various factors into r atings of sub-basin or watershed health, and that it would be best to cease use of EMDS for this purpose. The model does, though, have several real uses--as an accounting tool, as an explanatory tool, as a means of highlighting needed data, and as a means of focusing attention and discussion. The direction that makes sense to me would be to continue use of the current (2.0) model as an accounting and explanatory tool (without pronouncements on overall conditions), while working to reassemble the elements into a much-revised, more legitimate model that will better serve the needs of NCWAP.

The flaw comes principally from 1) the apples-and-oranges nature of the factors and how they are combined in the model, and 2) the different kinds of measures used for the reference curves (absolute measures vs. percentile in watershed). Because apples are combined with oranges, there is no scientifically legitimate way to combine the factors in their current form using relations as in the current model. Any refinem ent of weighting or combination rules will be futile. When the contrasting measuring scales are added to the confusion, hope of meaningful measure is further lost. So I believe that fiddling with details of the current model amounts to a side -show that will not be productive.

The model does have real value as an accounting tool. I believe it can be substantially improved to become a good accounting tool, one that combines factors using consistent measures in a logical way. This will take a major overhaul of the model's structure, and force it to become somewhat more physically based (for example, using sediment budgets to allocate between the effects of roads and upland). I think, though, that a reasonably tidy model that does this is within reach. Such a model would clarify the real interrelations, as in George Ice's comments, permit the "hazard vs. value" analysis mentioned by Steve Levesque, yield credible comparisons of the relative effects of different factors, and yield credible comparisons of health among watersheds. The current model is not capable of these things, though the model's description is vague enough that the reader might think it is.

I see this modeling as important because its real purpose is a conceptual map of the water shed system. In the current model, most of the pieces are on the table, so to speak, but, in my opinion, they need to be properly assembled. It is difficult to describe modifications of the model without conversation, and I would be willing to pursue the question further with interested folks if that seems useful.

Show data needs

One valuable contribution in the model's role as an accounting tool would be more explicit portrayal of data needs, an issue raised by Cathy Bleier on day two. I think a visual representation of data adequacy would be a major contribution of the EMDS accounting department. See suggestion #2 of my review of the three watershed reports.

Keep all data sources included using SOR nodes

Keep sources of incomplete but de tailed data (such as stream-reach conditions) in EMDS using SOR nodes, so as to clarify where that data fits in and to leave the door open to its use when fully available.

I know there's more to say, but this will have to do for now. That was a great meeting of fine folks,

Steve Ellen

Appendix 6 - David Lewis Comments

Review Comments

of the

North Coast Watershed Assessment Program
Ecological Management Decision Support (EMDS):
Watershed Condition and Stream Reach Condition Models

David J. Lewis
UCCE Watershed Management Advisor April 2002

The following is a summary of additional comments and suggestions following review of the Watershed Condition and Stream Reach Condition models developed by North Coast Watershed Assessment Program (NCWAP) staff. This staff has made significant gains in forming these models that attempt to use data, information, and policies from the five NCWAP participating agencies. The effort has been productive and useful for watershed management in California and will facilitate future data management and interpretation, as well as decision-making.

In general, the models present a useful structure and synthesis of existing watershed data and the current knowledge of watershed suitability for salmonid species. In this capacity the model can inform us on the current condition of North Coast watersheds. However, caution should be exercised in using the final designations of planning watersheds suitability because of the assumptions the models use and the lack of data to populate them. Assumptions include the implication that all planning watersheds are or were functioning anadromous fish habitat. Examples of data gaps include the lack of stream flow measurements or road density. Given the assumption and data drawbacks in the models, the real product and information from these tools are the model decision trees and node scores. These can serve as education and decision making tools for multiple stakeholders and agencies.

Additional comments and suggestions follow.

- Use of Department of Fish and Game stream survey data: It was openly acknowledged during the peer-review meeting that DFG stream survey and habitat assessment data was not collected to serve as long-term monitoring data. It appears that despite this acknowledgement, the stream reach model was developed to use the data available through stream surveys. An alternative approach would be to develop the reach model based on current knowledge of salmonid habitat and then populate the model with the data that fits that model.
- Breakpoints: As a first approximation of parameter interaction with anadromous fish, it is appropriate to establish breakpoints based upon values in the literature or reference conditions and watersheds were available. These should be consistently improved upon by data collection and ground truthing of assumed breakpoints. Changes in stream canopy cover, as a function of stream width, is a good example of how data informs breakpoint determination through description of system variability.
- Land Use including Roads: In addition to determination of land under differing land use (intensive, timber, extensive) or roads by density and distance to streams, the models could account for best management practice implementation. For roads this includes

surface treatment, drainage density, and culvert installation and risk of failure. In the case of farmed land, the absence or presence of cover crops and no-till practices are important influences on hydrologic, soil erosion, and sediment delivery processes. This will be important as recognition of resource manager and landowner efforts, motivating their involvement in watershed restoration and data sharing. In addition, these designations will create model nodes that track watershed condition changes in response to management decisions.

- Stream Temperature: It would not be appropriate to infer stream temperature for a planning watershed based on point data collected at either the upper or lower ends of the catchment. Stream temperature is best measured as a system wide parameter with a series of data collection points that can describe temperature throughout the entire watershed. It may be helpful to use rates of heating and cooling between monitored points instead of point calculations of MWAT. Rates provide indications of were heating and cooling is most rapid thus facilitating an understanding of reach temperature dynamics.
- Table of model results: The node scores as they relate to the final suitability designation for each planning watershed are the most informative component of the models. Presentation of these results can be complimented upon through the inclusion of a table that summarizes node scores for each planning watershed. An example table is provided below.

		Upland Condition				Stream Condition	Roads
Watershed	**Condition**	**Total**	**Upland Cover**	**Land Use**	**Slope Stability**	**Total**	**Total**
May	Moderate	High	High	High	High	Moderate	High
Minor	Low	Moderate	Low	Moderate	Moderate	Low	Low

- Model Calibration on Reference Watersheds: Model capabilities and effectiveness can be informed through model calibration of identified reference reaches and watersheds. These reference reaches and watersheds should consist of both anadromous and nonanadromous sites. Reference sites do not have meet pristine pre-European conditions, if indeed these even exist. They should instead represent target conditions that support salmon within the level of natural resource management and agricultural production anticipated in North Coast watersheds.

Appendix 7 - Eric Shott Comments

Delivered-To: standifo@nature.berkeley.edu
Date: Tue, 23 Apr 2002 08:57:37 -0700
From: Eric Shott <Eric.Shott@noaa.gov>
Organization: National Marine Fisheries Service
X-Accept-Language: en
To: Rick Standiford <standifo@nature.berkeley.edu>
Cc: RUSS_HENLY@fire.ca.gov, Cathy Bleier <cathy@resources.ca.gov>
Subject: Re: EMDS Review

Rick,

Unfortunately I was unable to get additional comments to you yesterday. NMFS will be sending further comment by written letter. Until that arrives, I'd like to offer some quick observations. Also, I'd like to receive a copy of a draft (preferred) or final write up of your summary of our comments at the peer review of EMDS.

Observations:

1. The uses and limitations of the model need better integration into the assessment reports.

2. The model needs to take into account the natural variability among river drainages better. And: the model often discards the idea that there are measures of habitat condition that can be applied across watersheds (taking into account the site specific variability- the use of reference watersheds) and instead defaults to condition calls based on the good and best conditions in each watershed. This dodges the question as to whether or not these conditions, including the best conditions in the watershed, are good or bad for salmonids.

3. If the modeling approach stays the same or similar, the model being built by EMDS should probably be broken into 2-4 separate models as suggested by several of the peer reviewers: current instream habitat condition, watershed potential/desired future condition, current land uses and risks.

4. The model attempts to identify problems at a very general scale when in many cases better, more site specific data are available for some North Coast watersheds such as sediment budgets. In my opinion, which is/was not shared by all the peer reviewers, sediment budgets and the like should not be used to weight parts of the model. Instead, the model should default to them or NCWAP should simply point out that better information at a site specific scale is available for a particular watershed and should be used by state agencies/stakeholders/etc.

5. The stream condition and reach condition models need rethinking.

6. Be careful tinkering with how the sub models add up the overall result. Without fixing the sub models this could easily be viewed as not based on an assessment of watershed conditions, but rather a desire to avoid many bad condition calls.

7. The USFS is using EMDS to produce what appears to me to be a better model of watershed conditions for salmonids. It's my understanding it will be used on the west coast, including CA. It would be useful for NCWAP's EMDS team to review their approach.

Eric Shott,
NMFS

Appendix 8 - Gary Nakamura Comments

Delivered-To: standifo@nature.berkeley.edu
X-Sender: sznakamu@mailbox.ucdavis.edu
Date: Fri, 19 Apr 2002 10:56:28 -0700
To: Rick Standiford <standifo@nature.berkeley.edu>
From: Gary Nakamura <gmnakamura@ucdavis.edu>
Subject: Re: EMDS Review
Status:

Hi Rick,

The major points I got at the meeting were the need for greater clarity on what the EMDS outputs mean, will be used for, and what they are not appropriate for. e.g. how EMDS will allow tracking from a "poor watershed condition" rating back to what specifically is the problem - temperature, sediment, lack of LWD. Also need to clarify or separate current condition from risks to future conditions (George Ice breakdown of the model), and better explain how the watershed rating (green to red color) reflects either current or future condition or some weighted average of them.

Gary

Comments on EMDS Anadromous Reach Condition Model from: Walt Duffy

The version of the Anadromous Reach Condition Model presented at the Santa Rosa meeting contained four primary elements; 1) water temperature, 2) riparian vegetation, 3) stream flow, and 4) in channel. Each element is supported by varying amounts of finer grained measurements and the their contribution to reach condition assessment will, therefore, vary.

Water temperature

In the model, water temperature can be considered from data on an annual 24 hr maximum, maximum 7-day average (MWAT) or maximum 7-day maximum. However, due to uncertainty, no water temperature data have been used.

While I don't find any of these measures compelling, I would favor comparing actual maximum 7-day average water temperatures with MWAT values for species, then reporting days MWAT was exceeded. If possible, I would suggest also reporting sum of degree days (accumulated temperature).

Water temperature should be incorporated into the model in some form.

Riparian vegetation

The model element for riparian vegetation can incorporate canopy density and riparian function, but presently does not use the latter. The difficulty and subjectivity of observers estimating tree size and health from the stream was discussed at the review, and I concur with concerns expressed there. However, I do think canopy composition and dead trees within some short distance (10 m?) could be assessed by observers with repeatability. When combined with canopy density, these two measures should give some estimate of 1) potential shading, 2) resistance to erosion and 3) potential wood recruitment.

Stream flow

Stream flow will be one of the most important model elements, but has not been incorporated into the model. Measures of stream flow relevant to anadromous fish to consider in this model element include, 1) summer base flow, 2) winter base flow, 3) frequency of peak flow and 4) annual discharge.

In channel

The model element for in channel includes substrate, pools, large woody debris, refugia and width/depth ratio. I believe the first three of these properties will be most useful in assessing stream condition for fish.

Substrate is proposed to be reported from one of several methodologies and I think that is acceptable. In the context of this model, the response by fish to substrate should not be viewed as a precise one. Rather, the model should identify large differences or categories of substrate.

The definitions for pool depth presented appear reasonable. Pool frequency is undefined. I suggest pool frequency in proportions approximately equal to riffles and runs (e.g. 33% each). Data I have looked at from better streams seems to support this, while pool frequency seems to decline in poorer habitat.

Pool frequency and quality should also be consider in the context of slop. High gradient streams will naturally have fewer and shallower pools.